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INFECTION IN THE LABORATORY

(Following is the translation of an article by Dr. J. Albrecht, (Trier), published in the German Language Periodical Deutsche Medizinische Wochenschrift (German Weekly Medical Bulletin), 1965, Vol. 37, p. 1637-1642. Translation performed by Constance L. Lust.)

The association with pathogens is among the duties of diagnostic and research labs, which are active in the medical-microbiological field. Working with human pathogens - such as viruses, rickettsia, bacteria, fungi and protozoa - involves certain danger for the personell. The association and extent of the danger are judged differently. Sometimes they are overestimated, but, particularly in the German literature are very often underestimated.

Wundt (34) wrote that the danger in hospitals and medical-microbiological labs is less than is generally assumed for physicians and their technicians. He says these workers are aware of the danger, and they know how to protect themselves under those conditions. Furthermore, the risk of infection is much less for technicians than for nurses, even though they are exposed to sources of infection such as tuberculous specimens like sputum, puss, urine and experimental animals. Patients may spread the TB bacilli by coughing and talking in an uncontrolled manner unknowingly. The lab worker, however, can prevent the dissemination of the bacteria very well by working carefully and cleanly.

Jensen (8) represents a group of authors who believe the following: In working with infectious materials only an accidental situation (aerosolization of liquids, injection) will result in infection. Several directors of laboratories concur with this point of view because they said that: "People in the lab should be careful that they don't drop anything, because then nothing will happen to them." The committee on TB of the "Accident Insurance Company of the German Central Committee for prevention of TB" recommended the conclusions of Jensen as the right course of action for the prevention of laboratory infection. (This conclusion was (Jensens(8)) that medical-technical assistants are not exposed to infection to a great degree.)

One may ask in what way the belief got started that working in a microbiological research laboratory is relatively non-dangerous; also why this belief is so widely accepted as true. I am of the opinion that this belief is completely erroneous. The following conditions undoubtedly contributed to the origin and spread of this concept: 1) Lab-personall

themselves standardized what is a dangerous germ in their work; 2) The fact that in Germany relatively few recognized cases of occupational-infection have occurred in laboratory workers; 3) Many new investigators don't recognize the origin of the danger or the method of transfer of infectious agents in the research laboratory.

Subjective Observations.

Laboratory workers, like all other persons working in hazardous occupations, have been advised and usually know just how dangerous a given material is. However, daily association with the danger diminishes the knowledge of it. Also, often safety measures are looked upon as exaggerated and unnecessary and it is a sign of cowardice and weakness if they are observed conscientiously. Some workers make it their duty to solve a problem without respect for their own well-being. There are indeed many examples of this in the history of microbiological research. In this connection Wedum speaks of a "Martyr of Science Complex" which leads to the thought, "Have the disease and get it over with" (30). On the other hand a laboratory director can "carry" his responsibility more easily if he believes the danger is minimal or non-existant. He can do this only because of rationalization not at all because of scientific knowledge. It is not surprising that a worker employed in a microbiological-lab belittles and underestimates his risks of infection by a germ, particularly if he is asked whether it be dangerous to work in such an atmosphere.

Frequency

Many authors base their judgement of the danger of infections on the number-lists from the occupational-accident appraisal. Brinkmann (5) belongs to this group. He reported that in Westphalia from 1950-1954 a total of 715 cases of occupational infection of TB were recorded. Grouped according to occupations they broke down as follows; 272 (39%) nurses; only 40 (6%) medical technicians. In the documents of Jensen (8) and Brinkmann (5) 3.1% and 3.2% medical technician respectively became occupationally infected with TB. The overwhelming numbers were again nurses. Both of these authors support their basic premise with these absolute statistics. (Premise - lab-workers are not necessarily unduly exposed to infections and are therefore only rarely endangered). They forget that there are many-fold more nurses than technicians. Without taking account of this fact they cannot make any assertations about the frequency of illness. Von Sulkin (24) reported a number of 2348 laboratory infections in his article. These occurred primarily in the USA, however, he gave no breakdown as to who is most suceptible to lab-infections. On the other hand Henze (7) set up a ratio of occupational illnesses to the number of persons in the particular occupation. He determined that of the occupational illnesses reported in Berlin laboratory technicians had a far greater percentage than nurses. Reid (21)proved that in England from 1949-1953 medical technicians

had a much higher percentage of occupational TB infections than did other medical workers. Furthermore, it was shown that pathologists and technicians had from two to three times the number of TB infections, which resulted in absence from work, than did similar occupations in the society as a whole. Particularly dangerous jobs were those that handled material for sectioning or the sputum from patients with tuberculosis. From these facts it must be concluded that laboratory work in pathology and bacteriology contains a definite danger, and that an infection of tuberculosis of the lungs may be contracted.

These arguments are perhaps based on faulty assumptions if one wishes to show specifically the ratio of occupational illnesses to the number of workers in a particular field. There are not enough data to allow comparisons among other types of medical-oriented occupations. In order to show the frequency of an occupational illness it may be necessary to relate the number of illnesses with the number of employees, as well as the number of man-hours (time at the occupation). In this way a completely different picture emerges of the frequency and of the risk of laboratory infection. Reid (21) and Henze (7) already explained this. The ignorance of these relationships probably leads to the conclusion that occupational illnesses of medical technicians occur less frequently than do illnesses in other hazardous occupations.

Causes

In the last 20 years research has been done, the results of which have measureably enlarged our knowledge about laboratory infections.

Even if careful technique is used during the course of experiments germs may nevertheless escape and endanger the laboratory workers. Pathogenic organisms are often transmitted through the air. Numerous procedures in the laboratory may cause spray or aerosol, which may contain germs. Johanssen and Ferris (9) were the first to demonstrate this in 1946. This observation was later confirmed by a group of English workers (18,29) and by several American workers (4,14,22,23,24,25,27,30,31,32). Manipulations that are known to produce aerosols are; centrifuging, crushing, pulverization, stirring, shaking, homogenization, and lyophilization. Furthermore handling of pipettes and scraping of loops also make aerosols. The danger to workers is all the greater, because this procedures are thought to be safe and the germs in the aerosol is produced unnoticed and remains undetected.

The size of the particle, on which, or inside which the germ is passed to the respiratory tract, plays a major role (12,13). Particles over 5 μ in diameter are usually held back in the upper respiratory tract. Often inhalation of such germ-infested particles illness are contracted that exert their effect in the upper part of the organ, such as diphtheria, whooping cough, measles, influenza, and respiratory streptoccii infections. Other pathogens must be deposited in those parts of tract that are not

protected by the ciliated epithelium in order to become infective. These germs must be in or on particles of less than 5 microns in diameter. Otherwise these particles are transferred to the outside by the ciliated epithelium before they become dangerous. In this group of germs are tubercle bacteria, fungi, histoplasma, coccidioides, as well as several viruses.

If germs are introduced into the respiratory tract in the form of aerosols that reach the lungs many pathogens cause illness that are not normally transmitted through the air-route. This has been reported for tularemia, brucella, glanders bacteria, rickettsia, as well as for yellow fever and encephalitis viruses (12,16,24,28). If these organisms are employed in a laboratory than airborne infections become a possibility.

In order to initiate an illness caused by microbes, very few pathogenic particles may be required if they happen to reach the right site in the host. A single tubercle-bacterium can cause a spot in the lung if the microbe is introduced directly into the lung via an aerosol (12,13). McCrumb (16) and Tigertt and coworkers (28) have shown that breathing in of only a few tularemia or Q-fever particles causes illness.

As science and technology advance, so do the number of occupation-associated infections that are produced because of aerosols. Also more and more pathogens are under investigation in laboratories. Wedum(31) believes that most lab-infections come about by the germ being transmitted through the air. Because of ignorance of the mode of infection many illnesses of lab-workers are thought to be contracted non-professionally. Sometimes a case is of the subclinical type, or perhaps even an inapparent infection. These cases may not lead to absences from work and are therefore never incorporated in the available statistics.

Conclusions

In the publication by von Wundt (34) one misses the references to the findings in the English and American literature. These references deal with the production of aerosols in laboratories and their significance in presenting danger to the health of the laboratory personnel. Contrary to von Wundt (34) these reports are of the opinion that: a) Working in microbiological lab is more dangerous than is generally assumed, b) the danger is by no means always known, c) an uncontrollable escape of germs is often impossible to prevent under usual working conditions in a laboratory.

Furthermore von Wundt does not emphasize the risk of tuberculosis infection in the laboratory. It is my opinion that a female medical laboratory technician is just as endangered in a laboratory where TB work is under investigation as a nurse in a TB sanatorium. Both the laboratory and the hospital room must be considered as infectious areas, particularly by means of an infectious aerosol which can get into the lung. In the laboratory these infected aerosols result from many technical manipulations,

whereas in the hospital the dangerous carriers, or spreaders produce small particles containing tubercle bacilli.

In order to have increased protection from infection for lab-personnel and for protection in case of a widespread infection the following useful points should be considered:

1) In order to diminish the danger of lab-infections it is necessary to expand training (education about danger) and to improve training methods (22,25,30,32,33). In England the bulletin "Safety Precautions in Laboratories" published by the Medical Research Council, contained a chapter about infectious aerosols (17). In building new laboratories, or renovating old ones, care should be taken to prevent spreading of germs by means of the ventillation system (air ducts).

2) It is not fully understood (6) that all pathogenic microorganisms, which are commonly studied in labs, are capable of causing infections in people, regardless of how they are transmitted. In this list the following are often missing; Adeno-, Echo-, Newcastle disease and Monkey B viruses, lymphatic cheriomeningetis viruses, as well as histoplasmosis and coccidioidomycosis. Occupational infections with these organisms have been reported (10,11,15,20,24,26,27,31,32). On the other hand Coli-dyspepsy is found primarily in infants. Another suggestion, not encompassed in reference (6), is that the term "infectious diseases" be replaced by "contagious transmittable diseases".

3) In illnesses that are caused or could be caused by pathogenic organisms commonly studied in laboratories, there is always a causal relationship between occupation, harmful effect, and illness, even if it was not possible to determine whether it was an accidental occurrance. If an infection source is found outside the occupation the risk of infection must be considered. Wedum (31) feels it is good policy to assume that all illnesses of lab personnel are occupationally associated until it has been proved otherwise.

Summary

The frequency and the risk of laboratory infections are often underestimated. Studies on the number of people infected in laboratories have shown that the possibility of an infection with pathogens, which are under investigation, is greater than is generally believed. The method of infection and the source of the infection may vary widely. The danger of infection is equivalent to that for people working in a hospital-station where infectious illnesses are treated.

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Concluding remarks by W. Wundt

I was happy to hear the presentation by Albrecht, because he describes the origins and occurrances of lab-infections which I did not encompass.

I have contrasted the danger of infection which may occur in a biological laboratory with other occupational infections, however, I have not underestimated them at all. This impression would not have occurred if Albrecht had read the quotations in context with the rest of the material in my paper. Noone can doubt that the number of infective illnesses has decreased; that TB has diminished; and that safety-measures for physicians and their technicians have become more effective. Because of these the risk of infection is no longer so great as before. As Albrecth quoted, even in the work of von Henze (1962) shows that the number of occupationally associated cases of TB have decreased markedly in West Berlin between 1950 and 1958.

According to Albrecht the danger of a tuberculosis infection in a sanatorium for TB is equal to that for a laboratory engaged in studying this infection. However, according to the generally accepted point of view the danger is greater for all people working in the hospital where contagious lung infections are treated. (See also Nieding: "Tuberculosis as an occupational illness", in Handbook for Arbeitsmedizin Volume II/1 Berlin-Munchen-Wien 1961) Even the supporting evidence of Henze (1961) and Reid (1957) don't help Albrecht in his reasoning in this case.

Reid did not report any number on the frequency of TB infection in treating-personnel (hospital) versus laboratory personnel. His work merely relates the statistics of the higher tuberculosis-morbidity of pathologists and their lab-technicians in contrast to the rest of the general populace.

Even Henze's (1962) report goes no further. He relates the frequency of TB of individual occupations with the total number of people employed in the particular profession. Only one such statement is worth expressing. From the statements of Henze it follows that the highest TB morbidity exists among the male hospital treating personnel: the physicians rank second; the lab technicians third; and nurses follow in fourth place. As Albrecht correctly stated, there are many more nurses than female medical-technicians. But, only a small percentage of these nurses is employed in hospitals where tuberculosis patients are treated. When statistics of this kind are used it is not surprising that nurses fare relatively well.

The extent of the danger of contracting a TB infection in a TB ward, where infectious aerosols are present, is elucidated by Riley's work (Bact. Rev. 25 (1961), 243). He subjected giunea pigs to air which had been obtained in a TB ward and observed a high rate of infection in the animals.

A number of techniques in the microbiological laboratory lead to formation of aerosols. These may contain infective agents and they may be inhaled.

In my presentation I could not go into details about details that are of interest only to specialists in this area. For example I did not discuss the work of Johansson and Ferris, and of Wedum. Without doubt these authors deserve great credit for pointing out that aerosols may contain infective germs. However, they do not discuss the risk of infection compared to that in a hospital ward.

Whether the inhalation of aerosols containing germs causes an infection depends upon several factors. Some pathogens cause especially many lab-infections, such as Tularemia, Brucella, Ornithosis, or Q-fever. However, others such as Salmonella or Shigella, as well as tubercle bacteria do not cause as many infections as the first-mentioned group. Albrecht quoted Langmuir (1961), who claimed that a primary tuberculosis may be caused by a single aerosol particle. If one accepts the suggestions of the accident insurance company and employs only tuberculii-positive personnel in the TB-laboratory then the picture is different. By-the-way Langmuir lists medicial students and nurses in first place as endangered personnel.

It is not desirable to discuss such different pathogens, as Tularemia and the tuberclebacteria, in the same breath. The safety measures of the laboratory orient themselves according to the pathogens under investigation. The protective measures are different in a Leptospirosis or Brucella laboratory than they would be in a Tuberculosis or Salmonella laboratory. The danger of the personell must be judged by the actual morbidity, not just by the circumstance that aerosols are produced during certain manipulations. Despite the opposition of Albrecht I still feel that nurses in a TB-hospital are in greater danger of contracting TB than are technical assistants(female) in a TB-laboratory. This is different for different illnesses. When treating a patient with Tularemia or Brucellosis the nurses are for all practical purposes not in great danger. However, laboratory personnel are endangered very much.

Also I can not substantiate Albrechts view that TB-illness of medical technicians may be considered to be an occupational illness in certain cases. The few cases of TB that occurred over the last 15 years in medical technicians and students (60-70 students per year) of the Tuebing Hygiene-Institute were always recognized as occupational illness.